Effluent Discharge and Dispersion through the South Bay Ocean Outfall

Environmental Review and Analysis for the Tijuana and Playas de Rosarito Water and Wastewater Master Plan

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1 Introduction

The U.S. Environmental Protection Agency (EPA) is participating in a planning study to determine the potable water and wastewater infrastructure needs of the Tijuana-Rosarito area, in the State of Baja California, Mexico. With funds from EPA, the Comision Estatal de Servicios Publicos de Tijuana (CESPT) has conducted a year-long effort to develop a comprehensive and dynamic plan that defines an integrated strategy for water and wastewater services to meet the needs of present and future generations in regard to public health, quality of life and environmental protection. This effort has culminated in the release of the draft *Tijuana and Playas de Rosarito Water and Wastewater Master Plan ("Master Plan"),* which evaluates options for long-term improvements to the potable water supply and wastewater treatment systems for these cities. As part of these improvements, the Master Plan proposes to dispose of wastewater effluent through a connection to the South Bay Land Outfall for its eventual discharge into the Pacific Ocean via the South Bay Ocean Outfall.

In compliance with the National Environmental Policy Act (NEPA), EPA has prepared an Environmental Assessment ("EA"). This EA analyzes the potential environmental impacts that may occur in the U.S., the transboundary impacts, from the activities proposed in the draft Master Plan. This memorandum has been written as part of the environmental review and analysis to evaluate the potential effects on water quality in the Pacific Ocean due to the additional wastewater flows discussed above.

This memorandum is heavily referenced to the 1997 CH2M HILL Technical Memorandum: *Appendix C: Effluent Discharge and Dispersion through the South Bay Ocean Outfall* ("1997 TM"). However, it is designed to be complete enough to be understandable as a stand-alone document.

The 1997 TM formed part of an Supplemental Environmental Impact Statement (SEIS) that evaluated secondary treatment options for wastewater discharge to the South Bay Ocean Outfall (SBOO) from the South Bay International Wastewater Treatment Plant (SBIWTP) (CH2M HILL, 1996). Although a secondary treatment alternative was chosen, it has yet to be implemented; the SBIWTP is currently discharging primary effluent.

The modeling results presented in the 1997 TM were based on oceanographic model results originally obtained by Parsons Engineering Science (1996) and will be referred to as the Interim Operation SEIS ocean modeling.

Now, however, it is necessary to assess the discharge from the SBIWTP with the additional flow rates proposed in the Master Plan. As described in Section 2 of the EA, three alternatives were chosen for further consideration, all of which allow for a

portion of the effluent to be injected into the regional aquifer. However, the flows that will be modeled in this TM are based on "the worst case scenario", i.e. peak projected flows with no groundwater recharge. In this case, the average flows, which are summarized along with the baseline SBIWTP flow in Table 1-1, are the same for each of the three alternatives. A peaking factor of 1.2 was used to determine peak flows, based on the peaking factor used in the Master Plan for maximum daily flow.

Table 1-1
Flow Rates (mgd) to be Assessed

	Average Flow	Peak Flow
Alternative 1 (FB)	38	45
Alternative 2 (FE)	38	45
Alternative 3 (GE)	38	45
Baseline (SBIWTP Flow)	25	50
Combined New and Baseline Flows	63	95

In all of the new cases, 100 percent of the flow is to receive activated sludge secondary treatment. Although the SBIWTP does not currently have secondary treatment, for the purposes of this modeling effort, it is assumed that the SBIWTP will incorporate a secondary treatment process for 100 percent of their flow.

2 Description of Discharge Area and Outfall

The SBOO alignment extends approximately 18,550 feet offshore into the Pacific Ocean, terminating at a depth of approximately 93 feet below mean sea level. The alignment begins 700 feet north of the U.S.- Mexico international border. The outfall pipe terminates in a "Y"-shaped diffuser, each leg of which lies at an angle of 120 degrees with respect to the main pipe, and to the other leg. The diffuser has three different diameter pipes (96, 78, and 54 inch), which decrease in size towards the terminus in order to maintain adequate velocity in the header to minimize the deposition of any settleable particles, and to maintain a flat invert to avoid trapping sediments. The diffuser consists of two 1,944-foot long sections with 81 vertical risers per leg, spaced 24 feet apart, with 4 ports per riser that are mounted on a turret. The port diameters range in size from 2.652 to 3.275 inches (CH2M HILL, 1997).

The location and layout of the South Bay Ocean Outfall and the regional features are shown in Figure 2-1.

The City of San Diego has been conducting water and sediment quality monitoring in the vicinity of the SBOO for several years. Current data are summarized in Section 3.3.2 of the EA. Baseline monitoring (pre-SBOO) conducted by the City in 1994 and 1995 showed the following (see the 1997 TM for a more detailed discussion):

- Winter conditions result in low thermal stratification, with bottom water temperatures reaching as high as 14.3 ^{o}C in December. In the summer, the water column becomes well stratified and is characterized by warm surface waters (up to 20.5 ^{o}C in June) and cold bottom temperature (as low as10.9 ^{o}C in July)..

- Salinity values were lowest in the fall (33.41 ppt) and highest in the summer (33.79 ppt).
- DO values decrease with depth and with distance from the shore, and are generally highest in the summer and the fall (reaching 8.9 mg/L), before declining through the winter (to 6.9 mg/L).
- The highest levels of suspended solids were found at depths of 30 feet or less.
- In general, there are two current patterns in the area: a uniform, dominant, north and south coast flow and a secondary large circulation cell that assists in transporting water away from the diffuser. A detailed description of the physical and chemical oceanographical features of the area is provided in Section 3.3.2 of the EA.

Insert Figure 2-1

3 Ocean Modeling

3.1 Initial Dilution

Southern California coastal ocean waters typically have minimal density stratification in winter, and varying intensity of stratification in the warmer months. The stratification tends to be greatest in late summer.

The initial dilution process occurs during the buoyant rise of the freshwater effluent plume from its discharge point on the seabed up through the water column. The greater the height of rise, the greater the initial dilution that is achieved.

When the sea is not stratified, the plume can rise nearly the entire height from sea bed to sea surface. When the sea is density-stratified, the plume rise may be limited to less than the full water depth, with correspondingly less initial dilution achieved.

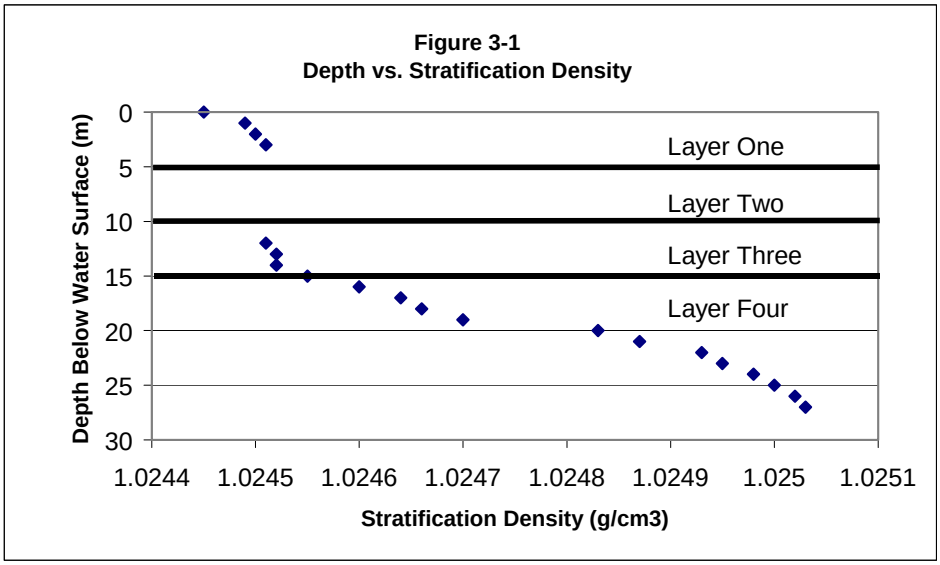
A typical density profile for late summer (August 1985), shown in Figure 3-1, has been used in the 1997 TM and in this memorandum to estimate conservative values for initial dilution (Figure 3-2) and for effluent plume submergence (Figure 3-3). In Figure 3-1, the top 5 m of the ocean is labeled, “Layer 1”; the 5 to 10 m depth interval is labeled “Layer 2”; the 10 to 15 m depth interval is labeled, “Layer 3”; and all depths greater than 15 m are labeled, “Layer 4”.

In the example of Figure 3-1, note that density is relatively uniform over the top 15 meters of the water column, then, in Layer 4, increases relatively rapidly with increasing depth.

A freshwater effluent discharged at, say, 30 m will float upwards, mixing with the deep, relatively dense lower ocean water. However, at a depth of about 15 m, the density of the mixture is no longer buoyant with respect to the ocean water above it, and the buoyant rise, and the initial dilution process, terminate.

Figure 3-3 shows that for a large range of effluent flow rate, Q, the terminal rise height is indeed in the neighborhood of 12 to 15 m. Figure 3-2 shows that for a large range of Q, the initial dilution is nearly constant at a value of about 88 to 90.

Figure 3-3 shows that the trapping level in late summer, which is probably the deepest trapping level to be expected, is in Level 3, for effluent Q of 40 mgd and greater. At some time in autumn, we may expect a sudden change from the late summer conditions to the well-mixed winter conditions. In winter, we may expect the plume, for all Q, to rise to the surface (Level 1), with greater initial dilution. In spring and early summer, we may expect trapping at Level 2, with initial dilution greater than in late summer but less than in winter.



The CH2M HILL initial dilution modeling results were partially based on modeling done in the Interim Operation SEIS performed by Parsons. This initial dilution modeling effort used a diffuser configuration that was different from the configuration described above and used by CH2M HILL. To determine if changes in configurations would affect modeling results, CH2M HILL ran a series of initial dilution runs with the dilution model UDKHDEN.

Previous initial dilution model results are summarized in Table 3-1. The comparison found that the change in the configuration resulted in the same or higher dilutions than earlier predicted; therefore the model is conservative in predicting the effects on receiving waters. Figure 3-2 is a plot of the initial dilution values in Table 3-1, vs. flow rate, with a dashed curve fitted to the "Final Design" points. The figure shows that for flows in the range of 63 to 95 mgd, the initial dilution ratio will be at least 83.

Figure 3-3, a plot of trapping depth values in Table 3-1, vs. flow rate, shows that for flows in the range of 63 to 95 mgd, the depth of submergence will be about 15 m for late summer conditions. Lesser depths of submergence may be expected at other times of the year.

The reader is referred to the 1997 TM for a more detailed explanation of this comparison (CH2M HILL, 1997).

Table 3-1
Initial Dilution Model Results (after 1997 TM)

Run No.	Flow (mgd)	Port Diameter (inches)	Port Spacing (feet)	Number of Ports	Dilution	Trapping Depth (feet below surface)
Configuration from Preliminary Design Report						
2	115	3.00	16	300	103.3	54.4
Configuration used for Interim Operation SEIS Ocean Modeling						
13	115	2.64	6	136	68.9	40.3
14	22.5	2.64	6	136	87.8	50.2
15	13.5	2.64	6	136	103.2	53.8
16	6.5	2.64	6	136	120.1	60.3
17	1.75	2.64	6	136	NA	NA
Configuration of Final Diffuser Design (1997 TM)						
18	115	4.57	24	81	83.0	49.7
19	22.5	4.57	24	81	119.2	48.4
20	13.5	4.57	24	81	130.9	51.3
21	6.5	4.57	24	81	NA	NA
22	1.75	4.57	24	81	NA	NA
23	115	5.70	24	81	115.9	
24	22.5	5.70	24	81	136.3	42.3
25	13.5	5.70	24	81	NA	NA
26	6.5	5.70	24	81	NA	NA
27	1.75	5.70	24	81	NA	NA

NA = Initial dilution model could not be run because of low port velocities. Typically dilutions will be higher than calculated for same conditions and greater flows.

Figure 3-2
Initial Dilution, vs Flow Rate

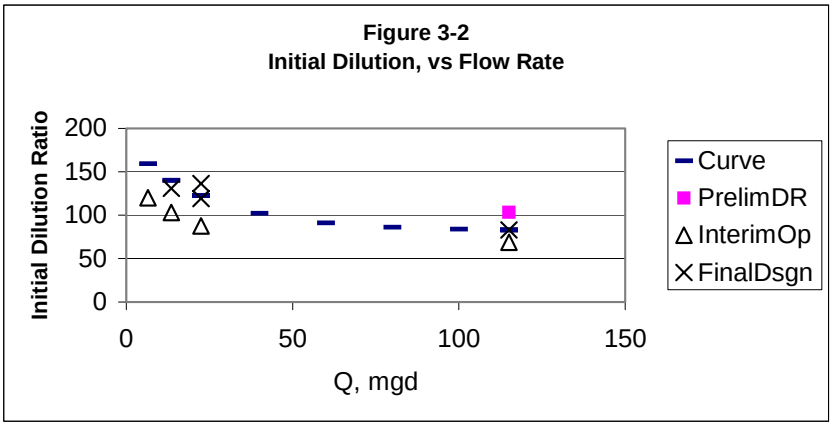
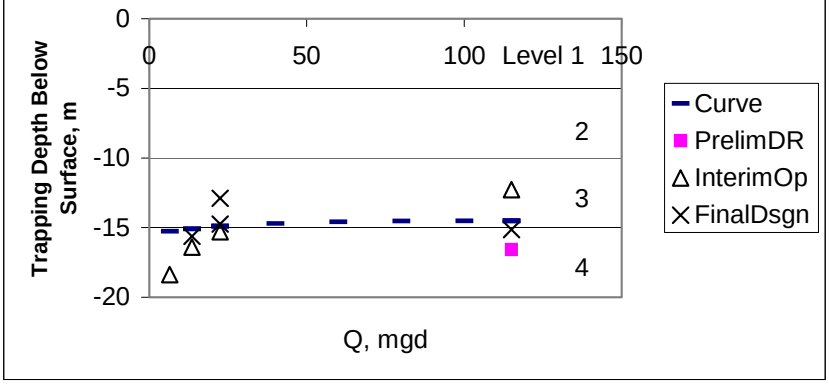


Figure 3-3
Trapping Depth Below the Surface, vs Flow Rate



3.2 Far-field Dispersion

Far-field modeling results are presented in contour plots for several depth bands, as labeled in Figure 3-3: Layer 1 (0 to 5m); Layer 2 (5 to 10m); Layer 3 (10 to 15m); and Layer 4 (>15m).

Interim Operation SEIS Far-Field Dilution Contours. The 1997 TM Figures 6.9A through 6.9D showed the predicted annual average far-field dilution contours along the US-Mexico Boundary as it extends seaward from the shoreline, and for similar transects 1, 2, 4, and 6 nautical miles south of the international border. Each of the four figures showed contours for one of the four layers.

The 1997 TM Figures A6.1 through A6.13 showed the predicted far-field dilution contours along the US-Mexico Boundary, for each of the four layers. Figure A6.1 showed the annual average condition; Figures A6.2 through A6.13 showed the contours for each of the 12 calendar months.

All those figures described the far-field dilution of a discharge whose average value is 27 mgd (1.18 m^3/sec). The left-hand vertical axis showed the relative dilution, c/c_o, expressed as a percent, where $c = c(x,y,z,)$ is the time-average concentration of a (conservative) effluent constituent at point (x,y,z) in the sea, and c_o is the concentration of that constituent in the effluent as it leaves the outfall. The right-hand vertical axis showed the relative dilution, i.e. c_o/c.

Dependence on effluent flux rate: The concentration of a conservative (i.e. non-decaying) constituent at any point in the sea, c(x,y,z), that is attributable to the SBOO is proportional to the mass flux of that constituent from the outfall, Qc_o, by the reasoning that constituent mass is conserved. That is, if one integrates the product of concentration c(x,y,z) times ambient flow velocity over the far-field flow cross-

sectional area (or areas), however one defines such areas and velocities, one should be able to account for all the mass flux, Qc_o. Therefore, assuming that the flow cross-sectional areas and the ambient velocities are, in the far field, independent of the outfall discharge, Q, then c(x,y,z) must be proportional to Qc_o.

Far-field concentration contours for a range of Qc_o. The Interim Operation SEIS far-field concentration contours were all for an effluent discharge rate of 27 mgd. Table 1-1, above, listed the new flow conditions to be examined, with average discharge flow rates, Q, ranging from 25 mgd to nearly 100 mgd.

The Interim Operation SEIS far-field contours are all reproduced, without a change in numbering, as exhibits within Figure 3-4 of this memorandum. However, there is one addition made throughout: in addition to the original vertical axes, labeled "27 mgd", there is a parallel set of vertical axes labeled "100 mgd," both on the left for percent relative concentration, and on the right for relative dilution.

The plots in Figure 3-4 show that the far-field dilution is at least 250, and usually much greater, for all seasons and locations, at discharge rates up to 100 mgd.

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4 Characteristics of the Effluent Relative to California Ocean Plan (COP) Regulatory Requirements

The regulatory requirements defined in the California Ocean Plan State Water Resources Control Board (SWRCD), *2001)* have not changed in essence since the 1997 TM was written. Specific details from the COP are presented in this section for direct comparison with our projected effluent characteristics. The reader is referred to the 1997 TM, and to (SWRCD, 2001) for a detailed description of COP requirements.

4.1 Effluent Flow

Flow rates to be examined in this analysis, presented in Table 1-1 above, range from 63 mgd (average) to 95 mgd (maximum). As shown in Section 3.1, the initial dilution ratios for this range are estimated to be about 83 to 90 in summer, when stratification is greatest, and the effluent plume is submerged at a depth of 12 to 15 m (i.e. in Levels 3 and 4). In winter, when the stratification is typically much weaker, the plumes are expected to rise to the surface (i.e. Level 1), attaining initial dilutions greater than found in summer.

4.2 Projected Effluent Concentrations and Limits for California Ocean Plan Table A Constituents

Effluent limitations for conventional pollutants are given in Table A of the COP. These limits, along with the projected average and maximum concentrations for the flows proposed in the Master plan are listed in Table 4-1.

Table 4-1
Projected Conventional Pollutant Effluent Concentrations for Activated Sludge Processes

Constituent (mg/l)	Ocean Plan Effluent Limits			Projected Average for Activated Sludge Effluent	Projected Maximum for Activated Sludge Effluent
	Monthly (30-day Average)	Weekly (7-day Average)	Maximum at any time		
TSS	See Note [1]			40	--
TKN	See Note [2]			30	--
CBOD5	See Note [3]			30	--
O&G	25	40	75	4	20
pH	6.0-9.0 at all times			6.8	8.6
Total Coliform (MPN/100 ml)	See Note [4]			200	400
Fecal Coliform (MPN/100ml)	See Note [5]			200	400

COP states:
1. "Dischargers shall, as a 30-day average, remove 75% of suspended solids from the influent stream before discharging wastewaters to the ocean, except that the effluent limitation to be met shall not be lower than 60 mg/l."
2. "Nutrient materials shall not cause objectionable aquatic growths or degrade indigenous biota."
3. "The D.O. concentration shall not at any time be depressed more than 10 percent from that which occurs naturally, as the result of the discharge of oxygen demanding waste materials."
4. "Samples of water from each sampling station shall have a density of total coliform organisms less than 1,000 per 100 ml (10 per ml); provided that not more than 20 percent of the samples at any sampling station, in any 30-day period, may exceed 1,000 per 100 ml (10 per ml)."
5. "The fecal coliform density based on a minumum of not less than five samples for any 30-day period, shall not exceed a geometric mean of 200 per 100 ml nor shall more than 10 percent of the total samples during any 60-day period exceed 400 per 100 ml."

4.3 Projected Effluent Concentrations for California Ocean Plan Table B Constituents

There are three classes of protection specified in Table B of the California Ocean Plan:

- Objectives for protection of marine aquatic given as 6-month median, daily maximum, and instantaneous maximum concentrations.
- Objectives for protection of human health (non-carcinogens) given as the 30-day average.
- Objectives for protection of human health (carcinogens) given as the 30-day average.

The expected effluent concentrations from the Master Plan were assumed to be the same as the concentrations listed in the 1997 TM for activated sludge treatment. The data used in the 1997 TM data were based on a two-year data set from the City of San Diego emergency connection from 1995-1996. These concentrations, along with the California Ocean Plan limits and currently feasible minimum levels of resolution, are listed in Tables 4-2, 4-3, and 4-4. The reader is referred to the 1997 TM for a more detailed discussion of effluent data sources.

Table 4-2
Ocean Plan Table B - Constituents Regarding the Protection of Marine Life and Expected Effluent Concentrations

Constituent (µg/l)	Ocean Plan Limits			Ocean Plan Minimum Levels	Average Concentra-tions for Activated Sludge Effluent	Daily Maximum Effluent Concentra-tions for Activated Sludge
	6 Month Median	Daily Maximum	Instanta neous Maximum			
Arsenic	8	32	80	1		
Cadmium	1	4	10	0.5	0.168	
Chromium (Hexavalent)	2	8	20			
Chromium (Total)					16.0	162.5
Copper	3	12	30	0.5	21.0	40.7
Lead	2	8	20	0.5	10.7	39.6
Mercury	0.04	0.16	0.4	0.2	0.212	0.7
Nickel	5	20	50	1.0	53.5	301.0
Selenium	15	60	150	1.0		
Silver	0.7	2.8	7	0.2	1.7	3.4
Zinc	20	80	200	1.0	49.2	135.5
Cyanide	1	4	10	5.0	1.6	7.1
Total Chlorine Residual	2	8	60			
Ammonia (as Nitrogen)	600	2400	6000	46800	30600	
Acute Toxicity (Tua)	NA	0.3	NA	NA	--	--
Chronic Toxicity	N/A	1	N/A			
Phenolic Compounds (non-chlorinated)	30	120	300		12.3	
Chlorinated Phenolics	1	4	10	0.1	BDL	
Endosulfan	0.009	0.018	0.027	0.07	0.07	0.07
Endrin	0.002	0.004	0.006	0.01	0.01	0.01
HCH	0.004	0.008	0.012	0.22	0.11	
Radioactivity						

Data from the 1997 TM.
BDL = Below Detection Limit
-- unavailable

Table 4-3
Ocean Plan Table B - Constituents Regarding the Protection of Human Health (non-carcinogens) and Expected Effluent Concentrations

Constituent (µg/l)	Ocean Plan Limits 30 Day Average	Ocean Plan Minimum Levels	Average Concentra-tions for Activated Sludge Effluent
Acrolein	220	2.0	
Antimony	1200	0.5	
Bis(2-chloroethoxy) methane	4.4	5.0	
Bis(2-chloroisopropyl) ether	1200	2.0	
Chlorobenzene	570	0.5	
Chromium (III)	190000		16 (Total Cr)
Di-n-butyl phthalate	3500	10.0	
Dichlorobenzenes	5100	2.0	
1,1-dichloroethylene	7100		
Diethyl phthalate	33000	2.0	
Dimethyl phthalate	820000	2.0	
4,6-dinitro-2-methylphenol	220		
2,4-dinitrophenol	4	5.0	
Ehtylbenzene	4100	0.5	
Flouranthene	15	0.05	
Hexachlorocyclopentadiene	58	5.0	
Isophorone	150000	1.0	
Nitrobenzene	4.9	1.0	
Thallium	2.0	1.0	13.2
Toluene	85000	0.5	
1,1,2,2-tetrachoroethane	1200		
Tributyltin	0.0014		0.005
1,1,1-trichloroethane	540000	0.5	
1,1,2-trichloroethane	43000	0.5	

Table 4-4
Ocean Plan Table B - Constituents Regarding the Protection of Human Health (carcinogens) and Expected Effluent Concentrations

Constituent (µg/l)	Ocean Plan Limits 30 Day Average	Ocean Plan Minimum Levels	Average Concentrations for Activated Sludge Effluent
Acrylonitrile	0.1	2.0	BDL
Aldrin	0.000022	0.005	BDL
Benzene	5.9	0.05	
Benzidine	0.00069	5.0	BDL
Beryllium	0.033	0.5	0.1
Bis(2-chloroethyl) ether	0.045	1.0	BDL
Bis(2-ethylhexyl) phthalate	3.5	5.0	2.67
Carbon tetrachloride	0.9	0.5	BDL
Chlordane	0.000023	0.1	BDL
Chloroform	130	0.5	
DDT	0.00017	0.01	0.042
1,4-dichlorobenzene	18	0.5	
3,3-dichlorobenzidine	0.0081	5.0	BDL
1,2-dichloroethane	28	0.5	
Dichloromethane	450	0.5	
1,3-dichloropropene	8.9	5.0	
Dieldrin	0.00004	0.01	BDL
2,4-dinitrotoluene	2.6	5.0	BDL
1,2-diphenylhydrazine	0.16		BDL
Halomethanes	130		
Heptachlor	0.00005		0.008
Hexachlorobenzene	0.00021	1.0	BDL
Hexachlorobutadiene	14	1.0	BDL
Hexachloroethane	2.5	1.0	BDL
N-nitrosodimethylamine	7.3	5.0	BDL
N-nitrosodiphenylamine	2.5	1.0	BDL
PAH's	0.0088		2.38
PCB's	0.000019	0.5	ND
TCDD equivalents	3.9E-09		3.23E-8*
Tetrachloroethylene	2.0	0.5	
Toxaphene	0.00021	0.5	BDL
Trichloroethylene	27	0.5	
2,4,6-trichlorophenol	0.29	10	BDL
Vinyl chloride	36	0.5	BDL

BDL = Below Detection Limit
ND = Non Detect
* Data taken from (USACEO, 1998)

5 Effects of SBOO Discharge

5.1 Conventional (California Ocean Plan "Table A") Constituents

In this subsection, the effects of the Table A constituents, as listed in Table 4-1 above, are discussed.

5.1.1 TSS: Sedimentation and Turbidity

Table 4-1 indicates that the projected effluent TSS levels will easily meet the Table A criteria.

Regulations for turbidity and suspended and settleable solids are described in Section II.C the California Ocean Plan and include the following:

- "The discharge of waste shall not cause aesthetically undesirable discoloration of the ocean surface."
- "Natural light shall not be significantly reduced at any point outside the initial dilution zone as the result of the discharge of waste."
- "The rate of deposition of inert solids and the characteristics of inert solids in ocean sediments shall not be changed such that benthic communities are degraded."

Sedimentation rates on the seabed in the area of the diffuser were originally predicted by the Interim Operation SEIS ocean modeling. The 1997 TM used these results to predict total and net sediment deposition rates for their proposed alternatives. The following is a summary of the approach used (the reader is referred to Section 6.5 of the 1997 TM for a more detailed discussion):

- The Interim Operation SEIS modeling used the assumption that the settleable fraction of the total suspended loading was 19.5 percent. That same fraction was applied to the alternatives proposed in the 1997 TM to estimate the settable solids effluent discharge concentrations.
- Total and net accumulation rates were calculated for the alternatives considered in the 1997 TM by assuming that they were proportional to the effluent sediment concentrations, i.e.,

$$Rates_{SEIS} / Rates_{1997TM} = C_{SEIS} / C_{1997TM}$$

- Total and net accumulation rates will be proportional to the mass rate of discharge, QC, of the effluent sediment:

$$(Rates)_{NEW} / (Rates)_{OLD} = (QC)_{NEW} / (QC)_{OLD}$$

- The Interim Operation SEIS modeling, and therefore the 1997 TM and the present analysis as well, derive the net accumulation rate by using a first-order decay of the 80 percent of the sediment that is assumed to be organic, at a rate of $0.1 day^{-1}$.

In the case of the 1997 TM, all of the alternatives were evaluated assuming the same flows. As previously noted, the estimated effluent TSS concentration in the new alternative proposed in the Master Plan is equal to 40 mg/L, which is equal to the TSS concentrations of alternatives 2 and 4a evaluated in the 1997 TM. Therefore, the results of the 1997 modeling can be used to estimate the total and net accumulation

rates of the new proposed alternative by assuming that the rates calculated in 1997 will be proportional to the new proposed flow rates, i.e.

$$Rates_{1997TM} / Rates_{MasterPlan} = Q_{1997TM} / Q_{MasterPlan}$$

The depositional rates in the area surrounding the diffuser (both total and net accumulation), are shown in Table 5-1 for the Interim Operation SEIS, the 1997 TM alternatives, and the new proposed alternative.

The Interim Operation SEIS modeling effort produced annual average deposition contours for total deposition and steady state accumulation rates. Using the same approach described above, these contours were modified to represent the current alternatives proposed in the Master Plan and are shown in Figures 5-1 and 5-2. Table 5-2 lists the areas between the contours shown and estimates the total sediment deposition and net sediment accumulation rates within the various contour lines The settleable solids analyses show that the additional flows proposed in the Master Plan will result in a net accumulation rate of approximately 2.4 mm / yr of material deposited on the sea bed near the diffuser. The predicted accumulation rates presented in Tables 5-1 and 5-2, and in Figures 5-1 and 5-2, may be considered to be conservatively large, for the following reasons:

- According to the 1997 TM, the Interim Operation SEIS ocean modeling deposition patterns were checked by comparison with the predicted deposition rates for the City of San Diego discharge off Point Loma, which were obtained using a more refined approximation to the mass distributions of particle settling speeds. Comparison of the two results indicates that the Interim Operation SEIS ocean modeling may over predict the deposition rate by a factor of about 2.2.

- According to NOAA Chart 18740, the seabed in the area of the SBOO diffuser is sandy, indicating no natural accumulation of fine sediments. Furthermore, the site, in less than 100 ft of water, is completely exposed to the Pacific Ocean wave climate, whose wave action at the seabed is easily capable of moving sand grains of up to 5 mm in diameter. Therefore, in a zone where coarse to fine sand can be easily moved, the very fine TSS particles from a secondary effluent would be very easily resuspended, and dispersed further.

Taking these two factors into account, it would still be conservative to estimate that net accumulation of settled, decayed, and frequently resuspended TSS would not exceed 1 mm / year in the neighborhood of the diffuser.

The COP states that “The rate of deposition of inert solids and the characteristics of inert solids in ocean sediments shall not be changed such that benthic communities are degraded” and “The concentration of organic materials in marine sediments shall not be increased to levels which would degrade indigenous biota.” The conservatively estimated net accumulation rate of 2.4 mm / year, diminished by the above factors to about 1 mm / year, is not expected to cause non-compliance with the

narrative requirements listed above due to the ability of dissolved oxygen to diffuse through depths greater than 1mm. Additionally, bioturbation, the disturbance of sediment layers by biological activity, is a significant process on the ocean floor and will help keep the seabed aerated. The predicted rate is lower than the threshold that could have any effects caused by direct burial, and is of the same order of magnitude considered as a natural sedimentation rate in this type of environment.

Table 5-1
Deposition and Accumulation Rates Near the Diffuser

	Effluent Sediments (mg/l)		Total Deposition Rate		Net Accumulation Rate	
Alternative	TSS	Settleable	g/m2/yr	cm/yr	g/m2/yr	cm/yr
Interim Operation Ocean Model	60	11.7	700	0.65	140	0.13
1, 3, 4a, 6*	21	4.1	245	0.23	49	0.05
2, 4b*	40	7.8	467	0.43	93	0.09
5*	88	17.2	1027	0.95	205	0.19
Master Plan	40	7.8	1176	1.08	234	0.23

*Alternatives considered in 1997 TM

Table 5-2
Annual Total Deposition and Net Accumulation Rate

Contours from Figures 5-1 & 5-2	Within A	Between A-B	Between B-C	Between C-D	Between D-E
Contour Internal Area (sq. km)	0.19	0.66	1.06	2.1	5.6
Annual Total Deposition Rate (metric tons/year)					
1, 3, 4a, 6*	46.6	92.4	74.2	73.5	100.8
2, 4b*	88.7	176.5	141.0	140.7	184.8
5*	195.1	387.4	310.6	308.7	408.8
Master Plan	223.5	444.8	355.3	354.6	465.7
Annual Net Accumulation Rate (metric tons/year)					
1, 3, 4a, 6*	9.3	18.5	14.8	14.7	22.4
2, 4b*	17.7	35	28.6	27.3	39.2
5*	39.0	77.2	62.5	60.9	84.0
Master Plan	44.6	88.2	72.1	68.8	98.8

*Alternatives considered in 1997 TM

Insert Figure 5-1

Insert Figure 5-2

5.1.2 CBOD and TKN: Constituents Affecting Dissolved Oxygen Demand

The California Ocean Plan requirements indicates that "the dissolved oxygen concentration shall not at any time be depressed more than 10 percent from that which occurs naturally, as the result of the discharge of oxygen demanding waste materials."

The 1997 TM listed four processes that could potentially affect the ambient D.O. levels:

1. Ambient DO is reduced during initial dilution through mixing with lower DO effluent, which occurs rapidly.

2. Organic materials in the effluent exert an oxygen demand on the receiving water while it decays. This has components that occur rapidly and others that take up to a few days. However, effluent dispersion continues through this process, therefore the largest effect is usually seen soon after the effluent is discharged.

3. Organic materials settle to the bottom and continue to exert an oxygen demand near the seabed.

4. Settled material can become resuspended and exert an oxygen demand in the water column, and can reduce effective dilution as low DO water is carried back to the wastefield plume.

A spreadsheet model that quantifies these four processes was used for predicting the effect of discharge on ambient DO levels over time. The following equation was used and includes the effects of the effluent discharge of DO and BOD:

$$DO(t) = DO_a + \frac{DO_f - DO_a}{Ds(t)} - \left[\frac{Lfc}{Ds(t)}\left(1 - \exp(-Kct)\right)\right] - \left[\frac{Lfn}{Ds(t)}\left(1 - \exp(-Knt)\right)\right] \quad (5\text{-}1)$$

where

DO(t) = Dissolved oxygen concentration as a function of time (mg/L)
DOa = Ambient dissolved oxygen (mg/L)
DOf = Final DO at the end of initial dilution (mg/L)
Ds = Subsequent (farfield) dilution
Lfc = Carbonaceous BOD (CBOD) above ambient after initial dilution (mg/L)
Lfn = Nitrogenous BOD (NBOD) above ambient after initial dilution (mg/L)
Kc = CBOD decay rate constant (per day)
Kn = NBOD decay rate constant (per day)
t = travel time (days)

and

$$Ds = \left[erf \left[\frac{1.5}{\left(1 + \frac{8e0t}{b^2}\right)^3 - 1} \right]^{1/2} \right]^{-1} \quad (5\text{-}2)$$

where

Ds = dilution attained after initial dilution as a function of travel time
erf = error function
b = effective diffuser length in feet
e0 = initial diffusion coefficient (ft^2/sec), equal to $0.001*b^{4/3}$
t = travel time in seconds

and

$$DO_f = DO_a + \left(\frac{DO_e - IDOD - DO_a}{ID} \right) \quad (5\text{-}3)$$

where

IDOD = Initial Dissolved Oxygen Demand after 15 minutes
ID = flux averaged initial dilution

and

$$Kc = 0.23\ (1.047)^{T-20}$$
$$Kn = 0.10\ (1.047)^{T-20}$$

Where T is the temperature in degrees Celsius, and

$$NBOD = 4.57(TKN)$$

Calculations were performed for the Master Plan proposed flows and, for comparison, the 1997 TM Alternative 1. This model assumed that the IDOD and the ambient BOD are equal to zero. Effluent BOD and TKN concentrations were assumed to be the same as those used in the 1997 TM. In order to represent the "worst case scenario", an effluent DO value of zero was assumed. Table 5-3 presents the input used in each scenario. The reader is referred to the 1997 TM for a more detailed discussion of data sources.

Figure 5-3 shows the DO sag curves for both scenarios. Figure 5-4 shows the percent reduction in the ambient DO with time. Both figures are useful in illustrating the small effect that the proposed effluent discharges would have on ambient DO

concentrations. The largest percent reduction in ambient DO levels that would be expected does not exceed 1.4 percent, which is in compliance with the California Ocean Plan requirements discussed above.

Table 5-3
Input Parameters for Comparative DO Sag Calculations

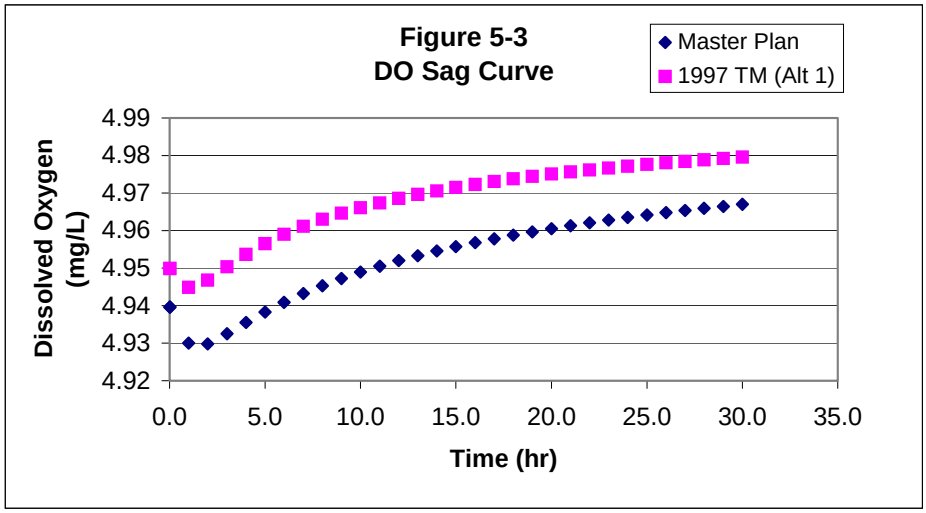
Parameter	1997 TM Alt. 1	Master Plan.
DO ambient (mg/l)	5	5
DO effluent (mg/l)	0	0
BOD5 ambient (mg/l)	0	0
BOD5 effluent (mg/l)	30	19
Initial Dilution, flux averaged	100	88
IDOD effluent (15 min0	0	0
TKN effluent (mg/l)	30	5.22
TKN ambient (mg/l)	0.4	0.4
Effective diffuser length (ft)	1872	1872

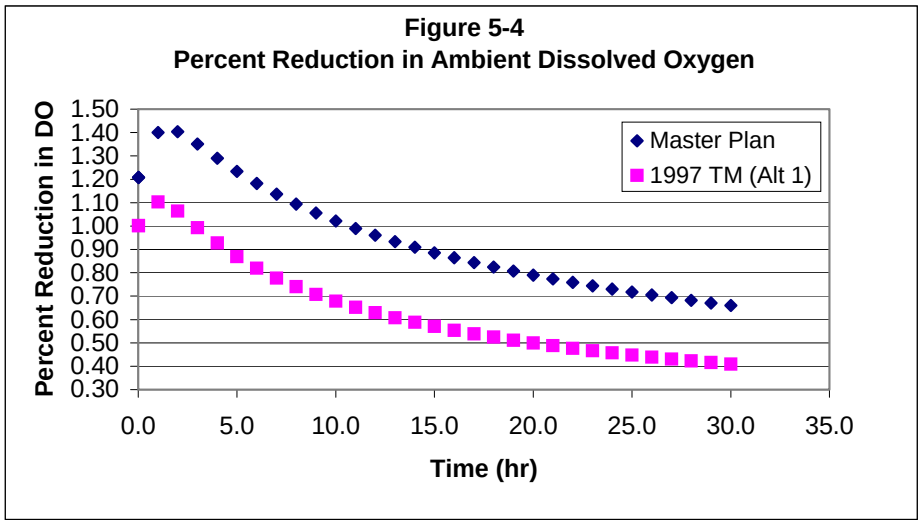
The Interim Operation SEIS ocean modeling addressed the calculation of the depression in ambient DO levels due to the passage of water over oxygen demanding sediments and due to the resuspension of settled organic material based on methods provided in the EPA 301(h) Technical Support Document. In order to estimate these values for the Master Plan, the same approach was followed that was used to estimate depositional rates in the previous section (5.1.1). The results are presented in Table 5-4.

Table 5-4
Predicted Effects of Deposition of Sediments on DO

	Effluent Sediments (mg/l)		DO Depression caused by Sediment Oxygen Demand		DO Depression caused by Sediment Resuspension	
Alternative	TSS	Settleable	mg/l	percent	mg/l	percent
Interim Operation Ocean Model	60	11.7	-0.12	-2.6%	-0.14	-3.2%
1, 3, 4a, 6*	21	4.1	-0.04	-0.9%	-0.05	-1.1%
2, 4b*	40	7.8	-0.08	-1.7%	-0.10	-2.1%
5*	88	17.2	-0.17	-3.8%	-0.21	-4.7%
Master Plan	40	7.8	-0.20	-4.28%	-0.25	-5.29%

*Alternatives considered in 1997 TM





5.1.3 Oil and Grease

Table 4-1 indicates that the projected effluent quality will easily meet the Table A criteria for oil and grease.

5.1.4 pH

According to the 1997 TM, the anticipated range of pH values in the raw influent range from 6.8 to 8.6. In the Interim Operation SEIS modeling, a pH value of 7.15 was used, based on measured values at San Diego's Point Loma outfall. Effluent pH range

for activated sludge secondary treatment may be assumed to be similar according to the 1997 TM. Therefore the California Ocean Plan criterion range of 6.0 to 9.0 for the pH of an effluent should be easily met.

In any case, the strong buffering capacity of seawater should resist any significant change in pH due to admixture—and dilution—of an effluent of different pH.

5.1.5 Coliform

For all alternatives in this analysis, the effluent considered is 100 percent activated sludge secondary effluent, disinfected. We therefore assume that the total and fecal coliform concentrations, at the point of discharge, meet the California Ocean Plan requirements.

5.2 California Ocean Plan Toxic ("Table B") Constituents

5.2.1 Compliance Factors: Initial Dilution and Minimum Level of Resolution

Compliance with the COP effluent limitations is determined by two factors: (1) if the concentration is greater than or equal to the Minimum Level, **and** (2) if the concentration of the pollutant is greater than the effluent limitation. The minimum levels for Table B constituents are defined in Appendix II of the COP and are based on detection levels. Effluent limitations are determined using the following equation:

$$Ce = Co + Dm\ (Co-Cs) \qquad [5\text{-}4]$$

Where

Ce = the effluent concentration limit
Co = California Ocean Plan limit (the concentration to be met at the end of initial dilution)
Cs = background seawater concentrations
Dm = minimum probable initial dilution expressed as parts of seawater per part of wastewater

5.2.2 Constituents Regarding the Protection of Marine Life

The constituents listed for the protection of marine life were listed in Table 4-2 above, showing the Ocean Plan limits, Co. These constituents are listed once again in Table 5-5, but this time showing the effluent limits, Ce, as computed from Equation 5-4. Following Figure 3-2, the initial dilution ratio, Dm, is assumed to be 83. The background concentration, Cs, is assumed to be zero. The Ocean Plan Minimum Levels, and the projected average and maximum effluent concentrations, are brought forward from Table 4-2.

The COP gives a limiting concentration (Co) for hexavalent chromium. However, the only available data for estimates of chromium concentrations in the effluent are given as total chromium. Given the conservative assumption that all of the chromium

present is hexavalent, the Master Plan flows should be in compliance with COP limitations. All other constituents also appear to meet the effluent limitation.

There are specific effluent limitations given for acute and chronic toxicity in the COP. The 1997 TM provided the concentrations for many of the constituents in COP Table B, however; it did not measure acute or chronic toxicity, which is used to estimate the combined / cumulative effect of the various constituents within an effluent based on standardized methods.

Initial monitoring of the SBIWTP beginning in 1997 showed regular non-compliance with acute toxicity limits. In response to this, a supplement to the 1996 SEIS was prepared in 1998 to address the issue. Additional testing of the SBIWTP effluent indicated that the effluent continued to exceed COP and NPDES limits for acute toxicity, and adverse impacts to water quality were concluded to be significant. In 1998, a Toxicity Identification Evaluation (TIE) was performed to identify the causes of the acute toxicity. The main source of toxicity was found to be surfactants; other sources included ammonia, zinc, and the pesticides diazinon and carbofuran.

Due to the conceptual nature of the Master Plan, it is not feasible to perform toxicity testing to estimate compliance with COP effluent limitations. However, some general comparisons with previous studies can be made. The effluent monitored at the SBIWTP is treated to an advanced primary level. Secondary treatment, such as what is proposed in the master plan, will substantially assist in reducing the concentrations of surfactants. Additionally, secondary treatment would help reduce the concentrations of pesticides and zinc. Secondary treatment is not expected to provide reduction in the concentration of ammonia; however, as shown in Table 5-5, the Master Plan effluent is projected to meet COP effluent limitations. The 1998 SEIS listed the use of a pretreatment program as a mitigation measure, requiring waste generators to treat wastes before discharge to the sewer. This, combined with the use of secondary treatment, will help Master Plan discharges meet the COP effluent limits for acute and chronic toxicity.

Table 5-5
Ocean Plan Table B Constituents Regarding the Protection of Marine Life
Effluent Limits

Constituent (µg/l)	Effluent Limits	Ocean Plan Minimum Levels	Average Concentra-tions for Activated Sludge	Effluent Daily Maximum Effluent Concentra-tions for Activated Sludge
Arsenic	672	1		
Cadmium	84	0.5	0.168	
Chromium (Hexavalent)	168			
Chromium (Total)			16.0	162.5
Copper	252	0.5	21.0	40.7
Lead	168	0.5	10.7	39.6
Mercury	3.36	0.2	0.212	0.7
Nickel	420	1.0	53.5	301.0

Table 5-5 Ocean Plan Table B Constituents Regarding the Protection of Marine Life Effluent Limits				
Selenium	1260	1.0		
Silver	58.8	0.2	1.7	3.4
Zinc	1680	1.0	49.2	135.5
Cyanide	84	5.0	1.6	7.1
Total Chlorine Residual	168			
Ammonia (as Nitrogen)	50400	46800	30600	46800
Chronic Toxicity	84			
Acute Toxicity	2.79			
Phenolic Compounds (non-chlorinated)	2520		12.3	
Chlorinated Phenolics	84	0.1	BDL	
Endosulfan	0.76	0.07	0.07	0.07
Endrin	0.17	0.01	0.01	0.01
HCH	0.34	0.22	0.11	
Radioactivity				
Data from the 1997 TM. BDL = Below Detection Limit				

5.2.3 Constituents Regarding the Protection of Human Health (non-carcinogens)

The non-carcinogenic constituents listed for the protection of human health were listed in Table 4-3 above, showing the Ocean Plan limits, Co. These constituents are listed once again in Table 5-6, but this time showing the effluent limits, Ce, as computed from Equation 5-4. Following Figure 3-2, the initial dilution ratio, Dm, is assumed to be 83. The background concentration, Cs, is assumed to be zero. The Ocean Plan Minimum Levels, and the projected average and maximum effluent concentrations, are brought forward from Table 4-3.

As mentioned the only available data for estimates of chromium concentrations in the effluent are given as total chromium. Assuming now that all of the chromium present is trivalent, the Master Plan flows should be in compliance with COP limitations. All other constituents also appear to meet the effluent limitation.

Table 5-6
Ocean Plan Table B-Constituents Regarding the Protection of Human Health
Effluent Limits

Constituent (µg/l)	Effluent Limitations	Ocean Plan Minimum Levels	Average Concentrations for Activated Sludge Effluent
Acrolein	1.85E+04	2.0	
Antimony	1.01E+05	0.5	
Bis(2-chloroethoxy) methane	369	5.0	
Bis(2-chloroisopropyl) ether	1.01E+05	2.0	
Chlorobenzene	4.79e+04	0.5	
Chromium (III)	1.60E+07		16 (Total Cr)
Di-n-butyl phthalate	2.94E+05	10.0	
Dichlorobenzenes	4.28E+05	2.0	
1,1-dichloroethylene	5.96E+05		
Diethyl phthalate	2.77E+06	2.0	
Dimethyl phthalate	6.89E+07	2.0	
4,6-dinitro-2-methylphenol	1.85E+04		
2,4-dinitrophenol	3.36E+02	5.0	
Ehtylbenzene	3.44E+05	0.5	
Flouranthene	1.26E+03	0.05	
Hexachlorocyclopentadiene	4.87E+03	5.0	
Isophorone	1.26E+07	1.0	
Nitrobenzene	4.12E+02	1.0	
Thallium	1.18E+03	1.0	13.2
Toluene	7.14E+06	0.5	
1,1,2,2-tetrachoroethane	1.01E+05		
Tributyltin	0.118		0.005
1,1,1-trichloroethane	4.57E+07	0.5	
1,1,2-trichloroethane	3.61E+06	0.5	

5.2.4 Constituents Regarding the Protection of Human Health (carcinogens)

The carcinogenic constituents listed for the protection of human health were listed in Table 4-4 above, showing the Ocean Plan limits, Co. These constituents are listed once again in Table 5-7, but this time showing the effluent limits, Ce, as computed from Equation 5-4. Following Figure 3-2, the initial dilution ratio, Dm, is assumed to be 83. The background concentration, Cs, is assumed to be zero. The Ocean Plan Minimum Levels, and the projected average and maximum effluent concentrations, are brought forward from Table 4-4.

Table 5-7
Ocean Plan Table B - Constituents Regarding the Protection of Human Health
Effluent Limitations

Constituent (µg/l)	Effluent Limits	Ocean Plan Minimum Levels	Average Concentrations for Activated Sludge Effluent
Acrylonitrile	8.40	2.0	BDL
Aldrin	0.002	0.005	BDL
Benzene	496	0.05	
Benzidine	0.006	5.0	BDL
Beryllium	2.77	0.5	0.1
Bis(2-chloroethyl) ether	3.78	1.0	BDL
Bis(2-ethylhexyl) phthalate	294	5.0	2.67
Carbon tetrachloride	75.60	0.5	BDL
Chlordane	0.002	0.1	BDL
Chloroform	10920	0.5	
DDT	0.014	0.01	**0.042**
1,4-dichlorobenzene	1512	0.5	
3,3-dichlorobenzidine	0.68	5.0	BDL
1,2-dichloroethane	10920	0.5	
Dichloromethane	37800	0.5	
1,3-dichloropropene	747	5.0	
Dieldrin	0.003	0.01	BDL
2,4-dinitrotoluene	218	5.0	BDL
1,2-diphenylhydrazine	13.44		BDL
Halomethanes	10920		
Heptachlor	0.61		0.008
Hexachlorobenzene	0.018	1.0	BDL
Hexachlorobutadiene	1176	1.0	BDL
Hexachloroethane	210	1.0	BDL
N-nitrosodimethylamine	613.2	5.0	BDL
N-nitrosodiphenylamine	210	1.0	BDL
PAH's	0.739		**2.38**
PCB's	0.002	0.5	ND
TCDD equivalents	3.276E-7		3.23E-8*
Tetrachloroethylene	8316	0.5	
Toxaphene	0.018	0.5	BDL
Trichloroethylene	2268	0.5	
2,4,6-trichlorophenol	24.36	10	BDL
Vinyl chloride	3024	0.5	BDL

BDL = Below Detection Limit
ND = Non Detect
* Data from USACOE, 1998

For carcinogens, three groups of compounds, PAHs and DDTs were found at levels that initially appear to be above the threshold COP standard. However, as discussed in Section 6.6 of the 1997 TM, the Ocean Plan Limits for both PAH and DDT are based on the summation of several compounds, of which some were detected and some were not. The average effluent concentrations for these three groups listed in Table 5-7 were estimated by adding the concentrations of those that were detected with the detection limits of those that were not. Therefore, the apparent non-compliance would not actually lead to a violation.

6 Summary

This section provides a summary of the analyses conducted, with each of the major constituents being addressed. It is intended to be brief; the reader is referred to the previous sections for more detailed discussions.

6.1 Coliform

The proposed effluent is considered to be 100 percent activated sludge secondary effluent, disinfected. We therefore assume that the total and fecal coliform concentrations, at the point of discharge, meet the California Ocean Plan requirements.

6.2 pH

The proposed effluent is predicted to meet pH effluent limitations and receiving water requirements.

6.3 Oxygen Demand

The proposed effluent is expected to meet the COP requirements regarding the depression of ambient DO levels in the receiving water.

6.4 Sedimentation

The proposed effluent is predicted to produce an accumulation of approximately 1 mm/yr of sediment on the seabed in the area surrounding the diffuser. The deposition rates fall off with distance from the diffuser. The predicted rate is lower than the threshold that could have any effects caused by direct burial, and is of the same order of magnitude considered as a natural sedimentation rate in this type of environment. Therefore, it is not anticipated that there will be any adverse effects on the seabed by the discharge.

6.5 California Ocean Plan B Limiting Concentrations

Using a minimal initial dilution of 83:1, the following predictions were made regarding compliance with the limiting concentration requirements listed in the COP:

- Protection of Marine Life: Compliance regarding acute toxicity is expected based on the use of a secondary treatment system. The limiting concentration requirements were met for all Table B constituents.

- Protection of Human Health (noncarcinogens): The limiting concentration requirements were met for all constituents.

- Protection of Human Health (carcinogens): The limiting concentration requirements were met for all constituents with the possible exceptions of PAHs, and DDT's, which were below the detection level of analyses.

7 References

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